suggested

CO-OP ELECTRIFICATION ADVISER TRAINING OUTLINE

14

GARDEN WATERING

REA

RURAL ELECTRIFICATION ADMINISTRATION U.S. DEPT. OF AGRICULTURE

4-50

PURPOSES OF THIS OUTLINE

This is one of a series of outlines prepared by REA as an aid in planning and arranging training schools for co-op electrification advisers. Each outline deals with a power use subject or with some aspect of cooperative theory and practice or with a particular method or technique of getting information to people. These are the three principal fields in which electrification advisers need to be skilled. In addition to subject matter, each booklet contains suggestions as to how the material might be presented, with a rough indication of a suitable time schedule. The booklet is thus useful as a guide to committees in charge of training schools, as a procedure guide to instructors, and as a subject matter manual that may be distributed to participants at the close of a training session for study and future reference. Subjects available or in preparation are listed below by title and number. *It is suggested that committees planning such training schools keep in mind the need of training in all three types of subject matter and, insofar as practicable, make use of the outlines in a balanced combination.*

LIST OF SUBJECTS

An ORIENTATION OUTLINE (unnumbered) covers all three fields of information. It is to provide the subject matter for an initial school that will give co-op officials basic background information and an understanding of the nature and scope of the educational job to be done.

NO.	POWER USE SUBJECT	NO.	CO-OP SUBJECT	NO.	METHOD OR TECHNIQUE
1	Farm and home Wiring	100	Value of Co-op	200	Getting News to Members
2	Farm Motors		Membership		(Newsletters and State
3	Water Systems and	101	Integrating Power		Paper Columns)
	Plumbing		Use and Co-op	201	Using the Radio
4	Electric Ranges		Education	202	Co-op Reports and Non-
5	Laundry Equipment	102	The REA Program		periodical Publications
6	Poultry Production		and Co-ops	203	Making Effective Talks
7	Refrigerators, Home	103	The Electric Co-op	204	Demonstration Techniques
	Freezers, Walk-Ins		— What It Is	205	Methods and Results of
8	Small Appliances	104	The Co-op Movement		Adult Education
9	Dairying		-- Here and Abroad		
10	Pig Brooding	105	Co-op Bylaws	206	Effective Meetings
11	Farm, Home and	106	Establishing Member		
	School Lighting		Ownership	207	Photography and Motion
12	Farm Shop	107	Assuring Member		Pictures
13	Pump Irrigation		Participation	208	Working witn Newspapers
14	Garden Watering	108	Co-op Tax Status	209	Exhibits and displays
15	Electric Hotbeds	109	Annual Meetings	210	Working with Rural Youth
16	Elevating, cleaning	110	Co-op's Place in	211	Working with Community
	and grading farm crops		the Community		Organizations
17	Drying grain, hay, peanuts,etc.	111	Cooperation Between Co-ops		
18	Heating, cooling, ventilating				
19	Cleaners, dish washers				
20	Kitchen planning				

TABLE OF CONTENTS

PROPOSED PROGRAM

This is a proposed program for one and a half days of instruction on garden watering. It is doubtful whether the subject can be covered adequately in less time, although a great deal more time could profitably be spent on the subject.

The instruction proposed here makes no attempt to teach electrification advisers how to install garden watering systems. Instead, it aims at teaching what needs to be known if farmers are to be advised soundly on what they need to know about this subject.

The "Suggested Instructors" indicated below are the types of persons who may be expected to give good instruction. Other persons with comparable background and experience may be equally well suited.

FIRST HALF DAY

Subject		Suggested Instructors
1. Purpose of instruction, introductions, welcomes, announcements, etc.	(15 min.)	Meeting chairman
2. The value of garden watering	(15 min.)	Extension specialist, Experienced gardener
3. Water needed a. Volume b. Depth c. Time of application d. Duration of each application	(30 min.)	Extension specialist
4. Limitations due to water supply a. Adequacy of source b. Size of well c. Suitability of water d. Depth of well e. Suitability of pumping equipment f. Capacity of pump g. Continuous and intermittent pump operation	(1 hr.)	Extension specialist, REA specialist, Manufacturer's engineer
5. Getting water to the garden a. Fitting pipe size to pump capacity	(1 hr.)	REA specialist, Extension engineer

SECOND HALF DAY

Subject		Suggested Instructors
6. Getting water to the garden (continued) b. Garden hoses - sizes and their significance c. Pipe and hose layout d. Hydrants and sill cocks	(1 hr.)	REA specialist, Extension engineer

SECOND HALF DAY (continued)

Subject		Suggested Instructors
7. Sprinklers a. Situations to which suited b. Types and sizes c. Characteristics of the various types d. Number used and arrangement	(1½ hrs.)	REA specialist, Extension specialist, Agricultural engineer
8. Porous hose a. Situations to which suited b. Weights and sizes c. Use characteristics	(30 min.)	REA specialist, Extension engineer, Agricultural engineer
9. Furrow a. Situations to which suited b. Layout and use c. Accessory equipment	(30 min.)	REA specialist, Extension engineer, Agricultural engineer
10. Underground tile a. Situations to which suited b. Layout and construction	(15 min.)	REA specialist, Extension engineer, Agricultural engineer

THIRD HALF DAY

11. Garden watering costs a. Materials b. Operation	(30 min.)	Extension specialist
12. Practice period a. Conditions for continuous pump operation (1) Capacity of pump against different pressures (2) Pressure loss at different rates of flow through pipe b. Distribution patterns of sprinklers (1) Rate of flow through sprinklers (2) Area covered (3) Uniformity of water distribution over covered area (4) Rate of water application to unit areas c. Water distribution characteristics of porous hose (1) Weights and sizes of hose (2) Rate of water delivery per unit length	(3 hrs.)	Meeting chairman, assisted by the various instructors

NOTE: No single instructor should be required to teach for more than two hours continuously.

SUGGESTED PRACTICE PERIOD ACTIVITIES

A. Determine the specific conditions under which a particular pump will run continuously.

Making an installation so that the pump will run continuously while the garden is being watered requires a knowledge of two things:

1. The capacity of the pump against different pressures.

2. The pressure loss at different rates of flow in the parts of the water distribution system.

(1) Determine the capacity at different pressures of the pump in one of the demonstration water systems.

(a) Through hoses or other means provide a source of water to the demonstration system so that the pump can run for 15 to 20 minutes without returning the pumped water to the reservoir of the system.

(b) Provide a pressure gauge on the pump or pressure tank so that the pressure against which the pump is working can be read at a glance.

(c) Provide a short outlet pipe on the storage tank of such size that water at the full capacity of the pump will flow through it at pressures of 15 pounds per square inch or less. In many cases, 3/4 inch pipe will be suitable. Install a valve in this pipe, or a faucet on its end, by which the rate of flow through it can be controlled. The outlet end of this pipe must be high enough and so located that the containers in which the water is measured may be placed under it.

(d) Start the pump and adjust the flow from the outlet so that the pressure against the pump remains constant at 20 pounds.

(e) With appropriate measuring containers (10 gallon milk cans are suitable) and a stop watch or the second hand on a watch, measure the time required for the pump to pump a predetermined amount of water, say, 10 gallons, 20 gallons, or 30 gallons. Record the time.

(f) Repeat steps (d) and (e) above with the pump operating against pressures of 25 pounds, 30 pounds, and 35 pounds.

(g) On cross-section paper plot the points obtained in steps (d) through (f) and draw a smooth curve through these points. This curve will represent the capacity of the particular pump being studied against pressures from 20 pounds to 35 pounds.

(2) Determine the pressure loss at different rates of flow in 100 feet of pipe.

(a) As the source of water use the demonstration water system for which the pump capacity at different pressures has already been determined.

(b) Provide a pressure gauge on the storage tank.

(c) Connect 100 feet of straight, level pipe to the outlet of the storage tank. Three-fourths inch pipe will be suitable for rates of flow up to 8 or 9 gallons per minute. One-inch pipe will be suitable for rates of flow up to 15 gallons per minute.

(d) On the outlet end of the pipe, install a tee with a pressure gauge in the side opening, and on the outlet opening of this tee place a valve or faucet by which the rate of flow through the pipe can be controlled.

(e) Start the pump and adjust the valve or faucet on the end of the long pipe so that the pressure on the storage tank holds constant at 20 pounds.

(f) As long as the pressure on the storage tank is constant, the rate of flow through the pipe must equal the pumping capacity of the pump. The capacity of the pump against 20 pounds pressure has already been determined. Find the rate of flow through the pipe by referring to the data already obtained on the pump capacity.

(g) Read the pressure gauge at the outlet end of the pipe. The difference between the reading of this gauge and the reading of the gauge on the pressure tank is the amount of pressure required to overcome the friction in this particular pipe at this particular rate of flow.

(h) Record the pressure drop in the pipe due to friction at this specified rate of flow.

(i) Repeat steps (e) through (h) with pressures at the tank of 25 pounds, 30 pounds, and 35 pounds.

Alternate method of determining pressure loss due to pipe friction.

This method may be used if water under pressure is available from a street main.

(a) Connect 100 feet of straight, level pipe to the water source with a pressure gauge at the point of connection.

(b) On the outlet end of the pipe, install another pressure gauge and a faucet to control the rate of flow.

(c) Open the faucet just enough so that there is a predetermined difference (say, 2 pounds) in the reading of the two gauges.

(d) With a suitable measuring container (possibly a 10 gallon milk can) and a stop watch or the second hand of a watch, determine the rate of water flow.

(e) Record the rate of flow which produced the predetermined pressure drop from pipe friction.

(f) Repeat steps (c) through (e) at 4 or 5 other pressure differences (say, 4 pounds, 6 pounds, 8 pounds, 10 pounds, and 12 pounds).

Caution - Do not attempt to use this alternate method if the source of water is a domestic water system. If such a system is used, the flow through the pipe will cause a continually varying pressure at the inlet end of the pipe with resulting confusion and inaccurracies.

B. Observe the distribution patterns of several different sprinklers.

There are three elements in the distribution pattern of a sprinkler, (1) the area covered, (2) the uniformity of watering over the covered area, and (3), the rate at which water is to be placed on a unit area.

At least three sprinklers will be needed for this practice activity. Each one may be needed in duplicate or triplicate if the capacity of the water system being used is such that one will not keep the pump running continuously. The three should include (1) a stationary lawn sprinkler of the doughnut, fan, or cone-spray type, (2) a common lawn sprinkler of the 2-arm, 3-arm, or 4-arm revolving type, and (3) an irrigation sprinkler of the hammer type which does not require either volume or pressure beyond the capacity of the water system.

There are several possible "set-ups" for observing the distribution patterns of sprinklers. The following directions will be suggestive and may need variation to fit the sprinklers and water system used.

(1) Comparing the areas covered.

(a) Connect one or more identical sprinklers to the water system for which the pump capacity at different pressures has already been determined. The number of sprinklers used will be that number which is necessary to keep the pump running continuously.

(b) Start the pump and read on the pressure gauge on the pump or tank the pressure against which the pump is operating. By referring to the data already obtained on the capacity of this pump, the rate of water delivery to the sprinklers may be determined. If the sprinklers are identical, it may be assumed that they are sharing this water equally and the rate of delivery of each sprinkler determined.

(c) Measure the radius or diameter of the area being wet by one sprinkler.

(d) Calculate the average rate of water delivery to each square yard of sprinkled area.

(e) Repeat steps (a) through (d) with each of the other two types of sprinklers.

(2) Comparing the uniformity of distribution over the sprinkled areas.

(a) While the sprinklers are operating in the comparison of the areas covered, (1) above, place several open-top, straight-sided tin cans along a radius of each sprinkled area.

(b) Allow each sprinkler to operate long enough to collect a measurable depth of water in each can.

(c) For each sprinkler, note the amount of water which fell on the ground at different distances from the sprinkler head, and compare the different sprinklers for the uniformity of water placed over the sprinkled area.

(3) Comparing the rates at which different sprinklers place the water on unit areas of ground.

(a) In step (d) under "Comparing the Areas Covered" above, the average rate of water delivery to each square yard of ground surface for each sprinkler was determined. Compare the different types of sprinklers in this respect.

(b) Calculate the time required for each sprinkler to place an inch of water over its sprinkled area.

(c) Assuming that no overlapping of sprinkled areas is necessary, calculate the number of different sprinkler settings and the length of time required for each sprinkler to place an average depth of one inch of water on 1/4 acre.

C. <u>Examine different weights and sizes of porous hose, and compare their water delivery rates</u>.

Porous hose is commonly made from canvas duck. The duck may be of almost any weight, but 8 ounce, 10 ounce, and 12 ounce duck are quite commonly used. The diameter of the hose may vary widely, but hoses in the range of 2 inches to 3 inches in diameter are common.

(a) Examine several sections of porous hose in a variety of weights of duck and sizes of hose.

(b) Attach a selected weight and size of porous hose (say, 8 ounce - 2 inches) to the water system for which the pump capacity at different pressures has already been determined.

(c) Start the pump and see whether it will run continuously within the pressure range for which its capacity is known.

(d) If the pump does not run continuously within the pressure range for which its capacity is known, shorten the section of porous hose or add additional sections as needed to bring it within this range.

(e) Determine the rate of water delivery from data already obtained for this pump.

(f) Calculate the rate of water delivery per yard of hose.

(g) Repeat steps (b) through (f) with several other weights and sizes of hose.

(h) Compare the rates of water delivery per yard of hose for the different weights and sizes of hose.

FACILITIES NEEDED FOR PRACTICE PERIOD

1. Ample source of water.
2. Demonstrator's water system.
3. At least two garden hoses.
4. At least two pressure gauges covering the range from 20 pounds to 40 pounds.
5. At least two containers for measuring water (10 gallon milk cans are suitable).
6. Short lengths of pipe and fittings for providing a suitable outlet to the pressure tank.
7. One hundred feet of pipe (size determined by pump capacity. Probably 3/4 inch or 1 inch).
8. At least one valve or faucet.
9. At least three sprinklers, including (a) a stationary lawn sprinkler of the doughnut, fan, or cone-spray type, (b) a common lawn sprinkler of the 2-arm, 3-arm, or 4-arm revolving type, (c) a small size irrigation sprinkler of the hammer type.
10. Tape measure.
11. Several open-top, straight-sided tin cans.
12. Several weights and sizes of porous hose.
13. Cross-section paper, pencils, and other facilities for taking notes and preparing rough charts.
14. Tools for connecting and disconnecting pipes and fittings, cutting and threading pipes, etc.

APPROPRIATE DEMONSTRATION EQUIPMENT

1. Four operating dealer's demonstration water systems - shallow well reciprocating, deep well reciprocating, jet, and shallow well turbine.

2. Various types of pipe and fittings.

3. Five-eighths inch garden hose.

4. Three-quarters inch garden hose.

5. A variety of types and sizes of sprinklers, including hammer type irrigation sprinklers.

6. Several sizes and weights of porous hose.

7. A "V" trough for distributing water to several rows for furrow-type watering.

SUMMARY OF USEFUL TECHNICAL DATA

1 cu. ft. of water weights 62.4 lbs.

1 cu. ft = 7.48 U.S. gal.

1 U.S. gal. of water weighs 8.34 lbs.

1 U.S. gal. = 231 cu. in. = .134 cu. ft.

1 barrel = 31.5 U.S. gal.

Ft. of head x .434 = lbs. per sq. in.

Lbs. per sq. in. x 2.31 = ft. of head.

1 H.P. = 746 watts = 33,000 ft.-lbs. per minute

450 gal. per min. = 1 acre-inch per hr. (approx.)

1 acre-inch = 27,152 gal. = 3,630 cu. ft. = 1/12 acre-foot.

Total head = Static head + suction head + pressure head.

$$\text{H.P. required} = \frac{\text{Cap. in gal. per min. x wt. per gal. x total head in ft.}}{\text{33,000 x pump efficiency}}$$

Pump efficiency depends on type of pump and head.

For rough approximations, figure pump efficiency of:

Reciprocating water system pumps	35% to 45%
Jet water system pumps	20% to 35%

WHAT IS GARDEN WATERING?

Before we start to study garden watering we should agree on what it is. Is it something different from irrigation? Depending on the point of view, the answer to this question can be either "yes" or "no". If we think of irrigation as the use of more or less highly specialized equipment and specially developed water sources for the purpose of applying water to a growing crop, the answer is "yes". If we think of irrigation as being merely the application of water to any growing plant, then garden watering is irrigation. Most of the literature on irrigation and most of the thinking of irrigation authorities is in terms of highly specialized equipment and specially developed water sources. For this reason, it seems desirable to use the term "garden watering" rather than "garden irrigation, when we are speaking of using the regular farmstead water system or similar equipment to water the home garden. When we are speaking of specialized equipment and special water sources for watering a commercial truck patch or market garden, it might be best to call it "garden irrigation". While this differentiation in terminology may not be authoritative, it does point out the limits of the subject matter in this manual, and it is probably what irrigation specialists have in mind when they say, "You can't irrigate with your regular farmstead water system".

WHAT IS GARDEN WATERING WORTH?

We need more information on the value of garden watering in the humid areas of the country. In the arid areas its value is unquestioned, but there has been a feeling on the part of many persons that in the humid parts of the country rainfall is ample and there is little or no need for supplemental water. Yet, in most years garden production in all parts of the country is reduced by periods of dry weather at some time during the growing season. During very dry seasons, watering may mean the difference between a good crop of high quality vegetables and a very small crop of low quality produce. More commercial market gardeners, even in the areas of well distributed, ample rainfall, each year are installing irrigation systems. For example, on Long Island, a highly developed market garden area, supplemental irrigation has become almost standard practice.

Very little literature has been published giving the actual monetary value that farmers have received from garden watering. However, one such publication is Virginia Agricultural Extension Service Circular E-352, May 1941, which contains the following:

> "Farmers have reported that watering their gardens, even during summers of normal rainfall, has increased yields of vegetables and small fruits as much as 50 percent. Evidence that garden watering pays is shown in the following information which represents averages for a number of farm gardens watered by a home pressure system:

"Average size of garden 85 feet x 100 feet
Value of vegetables and small fruit raised $135.40
Increase in yields due to watering 52%
Increased value due to watering (based on market price of vegetables) $44.13
Electricity used during season 15 KWH
Total water applied during season (gallons) 9,000
Electricity cost at 3 cents per KWH $0.45
Cost of watering unit $10.02
Total cost for season, including labor, depreciation, and electricity $3.08."

If we know how much garden watering will increase the value of a garden and how much it will cost each year to operate the watering system, we can easily calculate the amount a farmer can afford to spend for his installation.

Suppose we assume that the value of almost any well-cared-for farm garden can be increased $25.00 per year, and that labor, maintenance, and power costs will be $5.00 per year. This will leave $20.00 per year to cover investment and depreciation costs. The depreciation on the equipment might be 7½ percent. The $20.00 would then give a return of 6 percent on an investment of $148.00. If the farmer's investment in his installation were only $60.00, the $20.00 would give him a 26 percent return on his investment.

WHEN AND HOW MUCH WATER TO PUT ON

Generally, garden crops need about an inch of rain every week or 10 days. The watering system should be planned so that all parts of the garden can be well watered by the time 10 days of drought have elapsed. Since it may take 3 or 4 days of watering to cover the garden, it may be necessary to start watering when there have been 5 or 6 days without a soaking rain.

While a thorough watering each 7 to 10 days is a good rule-of-thumb, there are situations where it is not the best rule. The desirable frequency will depend on the crop and the soil. The Agricultural Extension Service of the University of California in a bulletin entitled Irrigation of Home Gardens, June 1943, gave the following data:

Suggested Frequency of Watering Vegetables

	Days Between Applications		
Soil Type	Shallow Rooted Crops (Down to 2 feet)	Moderately Deep Rooted Crops (Down to 4 feet)	Deep Rooted Crops (Down to 6 feet)
Sandy	4 - 6 days	6 - 10 days	10 - 12 days
Loam	7 - 10 days	10 - 15 days	15 - 30 days
Clay	15 - 20 days	20 - 30 days	30 or more days

One inch of water at each application is a rule-of-thumb that is generally good but is subject to occasional exceptions. In all cases, each watering should wet the soil to the depth that the roots go. If too little water is put on, a large part of it will evaporate, with little benefit to the plants, and shallow rooting will be encouraged.

The time required for a sprinkler to put on an inch of water can be determined by placing several tin cans in the area being sprinkled and seeing how long it takes for an inch of water to collect in them. Several cans at different distances from the sprinklers are needed because water will not be distributed evenly over the sprinkled area.

It is better to apply water slowly to a large area than to apply it rapidly to a small area. Slow application gives time for the water to soak in, and prevents erosion and waste of water through run-off.

It is sometimes best to water the garden in the evening or at night. Less water will be lost by evaporation then and the pump will be furnishing the water at a time when it will be called on to furnish less for other purposes. This is important on many farms since at certain times of the day almost the full capacity of the pump is needed for the other farm needs. If the garden is being watered at the same time, the amount of water available for other uses will be greatly reduced and the garden watering equipment will not operate at its best.

Garden authorities differ in their opinions of the best time to water. Some of them point out that drops of water on the leaves of plants while the sun is shining may "scald" the leaves due to the lens action of the water drops. Others think that leaving the leaves wet in the evening or early night is even less desirable because the leaves dry off slowly at these times and some diseases spread when the leaves are damp. This disadvantage can be largely overcome by applying the water slowly enough so that it takes all night to put on enough. While the leaves are being sprinkled there is little opportunity for disease spores to settle on the leaves and remain there, and the leaves dry off quickly when the sun strikes them in the morning.

VOLUME OF WATER NEEDED

How much water is needed to put one inch of water on a garden? One inch of water on an acre (1 acre-inch) is 27,152 gallons. This figure is easy to calculate when we remember that an acre is 43,560 square feet, so that an acre-foot of water is 43,560 cubic feet. Since an acre-inch is 1/12 of an acre-foot, an acre-inch of water is 3,630 cubic feet. There are 7.48 gallons in a cubic foot. 7.48 x 3,630 is 27,152.

Very few farm home gardens are as large as an acre. For the sake of an example, let us assume that a typical garden is 90 ft. x 120 ft. This is 10,800 square feet or almost 1/4 acre. One inch of water on this garden would be approximately 6,750 gallons.

While it is easy to figure out these quantities, a quantity that can be remembered is that each 1,000 square feet needs about 625 gallons each time it is watered.

If we were watering our 90 ft. x 120 ft. garden with a pump that delivers 250 gallons per hour, 27 hours of continuous pumping would be necessary to get the needed 6,750 gallons, and this would allow no water for any other use. Most farm pumps are selected to meet the other needs for water about the farmstead. Generally, these other needs require most of the pump's capacity at certain times of the day. Because of this limited pump capacity, garden watering can seldom be continuous through 24 hours. It may be desirable to water our garden only between the hours of 9 or 10 o'clock at night and 5 or 6 o'clock the next morning. The 27 hours of pumping for one complete watering would then be spread over 3 to 5 days. In other words, a farmer with a 90 ft. x 120 ft. garden and a 250 gallons per hour pump would, in dry weather, be watering his garden about one-half of the time.

IS THE WATER SOURCE ADEQUATE?

The most common limitation on the possibilities of garden watering is a water source that will not furnish water fast enough. Each time the garden is watered the pump will run continuously for several hours. This means that either the source must supply water at a rate equal to the pumping rate or the pump must draw the water from storage having enough capacity to supply the pump for this length of time. Before a farmer installs garden watering equipment he will want to assure himself that he has ample water.

Water for gardens may come from a wide variety of sources - wells, springs, cisterns, ponds, lakes, streams, reservoirs. However, if the regular farmstead pump is being used, the source will be that which supplies the other farmstead needs. The most common source is wells. Usually, the farmer knows his well better than anyone else, but in deciding whether it is adequate he should be reminded that the demand will be continuous for a considerable time.

The increased value of the watered garden will determine how much money a farmer can afford to spend to improve his well so that it will be adeouate. Of course, if he was considering an improved well for other reasons, garden watering will help to pay the cost.

THE WELL MUST BE LARGE ENOUGH

Sometimes wells are cased with such small casing that only small capacity pumps can be installed in them. This may limit the rate that water can be pumped from them even though the wells themselves are capable of supplying water at very ample rates. Different types

and sizes of pumps vary considerably in the amount of space that they require in the well. Some pumps can be used in casings as small as two inches. Most of the usual farmstead pumps can be used in four inch wells. While well size is not commonly a limiting factor in garden watering, it is one of the factors that needs to be considered if a new pump is to be installed.

IS THE WATER SUITABLE?

In most parts of the United States almost any available water is suitable for garden watering. With very few exceptions the water used for domestic purposes will not harm the soil or plants. However, there are exceptions. Particularly in the arid sections of the country some waters are salty or strongly alkaline. In some cases, the concentration of these harmful substances is low enough so that the garden could be satisfactorily watered a few times, but repeated watering would build up a concentration in the soil that would be harmful. The suitability of the waters is usually known locally.

IS IT ECONOMICAL TO PUMP FROM A DEEP WELL?

Increasing the height that the water must be lifted will increase pumping costs, but it is unlikely that the lift from any well used for regular farm home water supply will be enough to make it uneconomical to water the garden.

Perhaps some information on the power required to lift water will be helpful. Each gallon of water weighs 8.33 lbs. One hundred gallons weighs 833 lbs. Lifting one pound of anything one foot is 1 foot-pound of work. Therefore, lifting 100 gallons of water from a depth of 100 feet would be 83,300 ft.-lbs. of work. Since one kilowatt-hour is 2,655,000 ft.-lbs., .031 kwh is used in lifting 100 gallons 100 feet. If our motor and pump are only 33 percent efficient, .093 kwh of electricity would be consumed. On this basis, pumping the 6,750 gallons needed by our 90 ft. x 120 ft. garden from a 100 foot depth would consume 6.28 kwh. If the lift were only 50 feet, one-half this amount or 3.14 kwh would be consumed, and a lift of 200 feet would consume 12.56 kwh.

Before using these figures in actual practice. remember and make allowance for three things:

1. They assume that the overall efficiency of the motor and pump is 33 percent. The actual pump used may be more or less efficient than this.
2. These figures give the amount of electricity used in lifting water but do not include the electricity that would be used in overcoming the friction between the pipe into the well and the water.
3. These figures do not include the power needed to force the water into a tank or through a pipe after it leaves the pump.

IS THE WATER SYSTEM PUMP SUITABLE?

There are two things that need consideration in deciding whether the water system pump is suitable for garden watering. These are:

1. When it is pumping against the needed pressure, does it have the necessary capacity?

2. Is it equipped with a motor that will not be damaged by continuous operation under full pumping load?

Under the discussion of Volume of Water Needed, page 12, it is shown that a pump delivering 250 gallons per hour would have to pump for 27 hours to adequately water a 90 ft. x 120 ft. garden once. It was also shown that under practical use a farmer with a 250 gallons per hour pump and a 90 ft. x 120 ft. garden would probably be watering his garden about half of the time during dry weather. With the proper watering equipment, this could be very practical. But since few people will start watering their gardens as soon as it stops raining, it is also probable that a pump of this size would not be very satisfactory with a much larger garden. Of course, a 500 gallons per hour pump could do a satisfactory job on a garden of twice this size.

The piping system from the pump to the garden and the means of water distribution in the garden should be designed and installed so that the pump will run continuously while the garden is being watered. Continuous operation of the pump will reduce the amount of electricity consumed, but even more important, it will eliminate the wear and tear on the pumping equipment caused by frequent starting and stopping. Also, a continuously running pump means uniform rate of discharge of the water in the garden. A pump which starts and stops as the water is applied in the garden means wide variation in water pressures and non-uniform distribution. The importance of continuous running to the life of the pumping equipment is not commonly recognized. Most of the garden watering equipment in use on farmstead water systems has been installed without regard to it. In most cases, neither the farmer nor the person who planned the system realized that they may have been shortening the life of the pumping equipment several years by this oversight.

However, a precaution should be observed. The motors on some water systems are overloaded for continuous running. This is more likely to be the case with jet pumps than with other types. If an overloaded motor is run for an extended period of time, it will overheat and be damaged. Manufacturers have long realized that in the usual daily use of a water system the pump seldom runs for more than 10 or 15 minutes at a time so that the overloaded motors do not have time to become hot enough to be damaged. When jet pumps (which are relatively inefficient) became common, some manufacturers took

advantage of this situation and overloaded their jet pump motors so that the operating efficiencies of the pumps would appear to equal or be superior to other types of pumps. The motors on other types of pumps will likely not be overloaded unless the voltage is low or their operating pressures have been raised. It is questionable whether pumps with overloaded motors are suitable for such purposes as garden watering. Of course, in some cases, they can be made suitable by replacing the motors with others one size larger. It would be well before attaching garden or lawn watering equipment to a jet pump to allow the pump to run for an hour or longer under load and then to check the motor temperature to see if it is overheating.

HOW CAN WE DETERMINE A PUMP'S CAPACITY AT DIFFERENT PRESSURES?

Most farmstead water system pumps are rated in the manufacturers' catalogs as having certain capacities under certain conditions. In actual installations, we seldom know how well these specified conditions are met, and consequently we do not know the capacity of any particular pump in a particular installation. We cannot do a good job of planning the garden watering unless we know the actual installed capacity of the particular pump. This may be of special importance in the case of jet pumps. The motor on a particular jet pump may not be overloaded and can safely operate for long periods of time if the pressure is 35 lbs., but at 20 lbs. it would be overloaded and damaged by continuous operation. In such a case it would be extremely important that the watering equipment be installed so as to maintain a pressure at the pump which would prevent motor overloading. In all cases, the pump capacity must be known if the watering is planned so that the pump will run continuously.

It is usually rather easy to determine the pump capacity at different pressures on a particular installation.

First, we must have a pressure gauge on the pump or storage tank so that we can tell at a glance what the pressure is.

Second, we must have a water outlet from the storage tank which we can control by a valve while watching the gauge.

Third, we must have a can or container of some kind into which the water flows as we open the valve in the outlet from the storage tank, and in which we can measure the water. A 10 gallon milk can is often suitable.

To determine the pump capacity, we adjust the valve in the water outlet, with the pump running, so that the pressure holds constant at the value for which we are checking the capacity. We then measure the time required for a certain amount of water to flow from the outlet and calculate the rate in gallons per hour or gallons per

minute. For example, if 1 minute and 45 seconds are required to fill a 10 gallon milk can, the capacity of the pump at that pressure is 343 gallons per hour. To get the capacity at another pressure, we then adjust the outlet valve so that the pressure holds constant at this other pressure and repeat the measurement.

HOW DO WE MAKE THE PUMP RUN CONTINUOUSLY?

Most electric water system pump motors are started and stopped by automatic switches. Usually, these switches start the motors when the water pressure at the pumps falls to 20 pounds and stop the motors when the pressure at the pumps reaches 40 pounds. If we install the garden watering equipment so that water at the full capacity of the pump is put on the garden when the pressure at the pump is below 40 pounds, the pump will run continuously while the garden is being watered. We can be sure of getting this situation by:

1. Proper selection of pipe sizes.

2. Using the correct number of sprinklers or other outlets in the garden.
3. Selection of sprinklers or other outlets of the correct capacities.

WHAT IS THE BEST WAY OF GETTING WATER TO THE GARDEN?

Unless the garden is close by a building with a sill cock or wall hydrant on the side, it is usually best to bury a pipe to the garden, place a frost-proof hydrant there, and use one or more garden hoses to take the water to the sprinkler or other means of distribution. Placing the frost-proof hydrant in the center of the garden will permit the use of the shortest lengths of hose and give most uniform water distribution on all parts of the garden. If the garden is small and close by a building with a sill cock or wall hydrant the cost of underground piping to the garden may not be justified. The garden hose then can be attached to the sill cock or wall hydrant.

There are several ways of putting water on the garden. Sprinklers are most common, with porous hose and furrows or ditches being used to a considerable extent. Underground tile is occasionally used.

HOW DO WE SELECT THE RIGHT SIZE PIPE?

Water will not flow unless there is pressure pushing it. In the case of a creek or river, this pressure is gravity (the weight of the water). In a usual electric water system, the needed pressure is produced by the pump and is equal to the pressure in the hydro-pneumatic tank. To explain how fast the water will flow, let us start with a very simple situation.

Suppose we have a pressure storage tank with a straight, perfectly level pipe leading from its bottom, with an open, free discharge at the far end. Figure 1 shows such a situation.

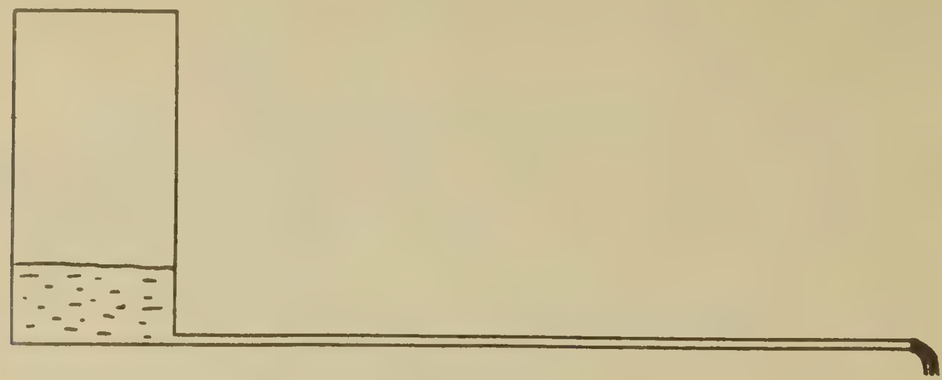

Figure I

Since the pipe is level, no pressure will be used up in lifting the water. All of the pressure will be used in making the water flow. The most important thing to remember in this or any other problem on pipe size, is that the rate of flow will become constant at that rate where the forces opposing the flow exactly equal those causing the flow. In our simple problem illustrated in Figure 1, the only force opposing the flow is the friction between the water and the pipe. Since the friction increases as the speed of the water increases, the rate of flow through the pipe will increase rapidly until the friction in the pipe is equal to the pressure in the tank and then it will remain constant as long as the pressure is constant. All that we need to know in order to tell how fast the water will flow from this pipe is the pressure in the tank and the amount of friction developed by different rates of flow. We then select the rate of flow at which the friction in the pipe and the pressure in the tank are equal.

We can find the pressure in the tank by putting a pressure gauge on the tank. We find the friction at different rates of flow by referring to tables. These tables are used in this way by all engineers. No one memorizes them.

Before we can read the friction tables we need to know a little more about how pressures are measured. One way is in terms of pounds per square inch, but there is also another common way. If we have water in any kind of a container, whether it be a cup, a tank, or a lake, the weight of the water is a pressure on the bottom and sides, and this pressure depends on the depth. Each foot of depth exerts a pressure of .434 pounds per square inch. To get 1 pound of pressure the depth would have to be 2.31 feet. This means that we can express pressures in terms of feet of depth of water as well as in pounds per square inch. A pressure equal to that developed by 1 foot of water is called 1 foot of head. A pressure equal to that of 25 feet of water is called 25 feet of head, and so on for other depths. From

this we can see that 1 foot of head is .434 pounds per square inch and 1 pound per square inch is 2.31 feet of head. In working on pipe size problems it is often necessary to convert feet of head to pounds per square inch and vice versa. Tables of water friction in pipes may be either in terms of pounds per square inch or in terms of feet of head. They are most commonly in feet of head so that is the way they are given here.

The friction in a pipe depends on the rate of flow, the roughness of the inside surface, the size of the pipe, and the length. As the pipe gets older, its interior surface gets rougher. Usually, the change is not great with materials such as copper or brass. It is considerable with steel.

Table I gives the friction in new copper tubing. Table II gives the friction in average steel pipe about 12 to 15 years old. For new steel pipe, the friction will be about 75 percent of that given and for 25 years old pipe it will be about 20 percent greater.

TABLE I

FRICTION OF WATER IN COPPER TUBING

Loss of Head in Feet* Due to Friction Per 100 Feet of Smooth Pipe (Type L Copper Tubing)**

Gallons per Min.	3/8" Tubing	1/2" Tubing	3/4" Tubing	1" Tubing	1-¼" Tubing	1-½" Tubing	2" Tubing	2-½" Tubing	3" Tubing
1	8.1	2.8	.46						
2	27.	8.8	1.5	.42					
3	53.	18.	3.0	.86	.32				
4	88.	30.	5.1	1.4	.52	.23			
5	130.	43.	7.6	2.1	.79	.35			
6	180.	60.	10.	2.9	1.1	.48			
7	230.	78.	14.	3.8	1.4	.62			
8		98.	17.	4.8	1.8	.79			
9		120.	21.	6.0	2.2	.97	.26		
10		150.	25.	7.3	2.7	1.2	.31		
15			51.	15.	5.5	2.5	.62		
20			85.	25.	9.0	3.9	1.0	.36	
25			125.	37.	13.	6.0	1.6	.53	
30			170.	49.	19.	8.1	2.1	.74	.30
35			230.	63.	25.	11.	2.8	.96	.40
40				79.	30.	13.	3.5	1.2	.51
45				98.	37.	16.	4.3	1.5	.64
50				120.	45.	20.	5.3	1.8	.78

*From Chart in Figure 7 of Report BMS66, National Bureau of Standards.

**Data is for new copper tubing with recessed soldered joints. It may also be applied to any correspondingly smooth pipe such as brass pipe

TABLE II
FRICTION OF WATER IN STEEL PIPE

Loss of Head in Feet* Due to Friction Per 100 feet of Fairly Rough Pipe**

Gallons per Min	3/8" Pipe	1/2" Pipe	3/4" Pipe	1" Pipe	1-¼" Pipe	1-½" Pipe	2" Pipe	2-½" Pipe	3" Pipe
1	17.	4.3	.59						
2	64.	16.	2.2	.51					
3	140.	35.	4.6	1.1	.40	.15			
4		60.	8.1	1.9	.70	.27			
5		92.	13.	3.0	1.0	.41			
6		130.	18.	4.2	1.5	.58			
7		175.	25.	5.8	2.0	.79			
8		230.	31.	7.4	2.4	1.0	.25		
9			38.	9.3	3.1	1.2	.31		
10			48.	11.	3.9	1.6	.39		
15			100.	26.	8.5	3.3	.85	.28	
20			180.	43.	15.	6.0	1.5	.48	
25				67.	23.	9.0	2.3	.74	.31
30				97.	32.	13.	3.1	1.1	.44
35				130.	43.	17.	4.2	1.4	.60
40				160.	55.	22.	5.3	1.8	.75
45				220.	69.	28.	6.9	2.3	.96
50					86.	35.	8.6	2.8	1.2

*From Chart in Figure 9 of Report BMS66, National Bureau of Standards

**Fairly Rough Pipe will approximate in many installations the condition of ordinary galvanized steel pipe after it has been in use 12 to 15 years.

The friction of water in an elbow, tee, globe valve or faucet may be assumed to equal that in 10 feet of straight pipe. The friction in gate valves, couplings, and unions may be neglected. A more exact evaluation of the friction in these fittings is given in Table III below, but this assumption is accurate enough for most applications. Faucets are essentially globe valves as far as friction is concerned.

TABLE III
FRICTION OF WATER IN VALVES AND FITTINGS

Allowance in Equivalent Length of Pipe for Friction Loss in Valves and Fittings

Size of Fitting	90° Elbow	45° Elbow	90° Tee	Coupling or Straight Run of Tee	Gate Valve	Globe Valve	Angle Valve
Inches	Feet	Feet	Feet	Feet	Feet	Feet	Feet
3/8	1	.6	1.5	.3	.2	8	4
1/2	2	1.2	3	.6	.4	15	8
3/4	2.5	1.5	4	.8	.5	20	12
1	3	1.8	5	.9	.6	25	15
1¼	4	2.4	6	1.2	.8	35	18
1½	5	3	7	1.5	1.0	45	22
2	7	4	10	2	1.3	55	28
2½	8	5	12	2.5	1.6	65	34
3	10	6	15	3	2	80	40

You will notice that Tables I and II give the friction in 100 feet of pipe. The friction in 50 feet of pipe is just one-half of that in 100 feet, and the friction in 200 feet of pipe is just double that in 100 feet. The friction in other lengths is also in direct proportion to the lengths.

Now, let us go back to the situation shown in Figure I and work out a few problems.

Problem No. 1 - If the pipe in Figure I is 1/2 inch galvanized steel 100 feet long and there are 40 pounds per square inch pressure in the tank, how fast will water flow from the pipe?

Solution to Problem No. 1 -

(a) Since there are 40 pounds of pressure in the tank, we know that the flow will become constant at a rate where the friction in the pipe equals 40 pounds.

(b) Since the pipe is galvanized steel we look at Table II to find the rate of flow that will produce 40 pounds of friction in 1/2 inch pipe.

(c) As we look at Table II we notice two significant things that must be considered before we can get our answer: (1) the table gives the friction per 100 feet of pipe (we have exactly 100 feet in this problem); and (2) the table gives the friction in terms of feet of head while we know it in our problem in terms of pounds per square inch. To convert our known friction of 40 pounds to feet of head, we multiply by 2.31 and find that it is 92.4 feet of head.

(d) We follow down the column headed "1/2 inch pipe" in Table II looking for "92.4". We find "92" which is practically the same.

(e) By reading to the left from "92" we find that a flow of 5 gallons per minute will produce 92 feet of friction head.

(f) This means that water will flow from the pipe at a rate of 5 gallons per minute.

Problem No. 2 - If, in Figure I, there is 30 pounds of pressure in the tank, and there is to be 250 feet of steel pipe, what size must the pipe be so that water will flow from it at a rate of 360 gallons per hour?

Solution to Problem No. 2 -

(a) Since Table II gives rates of flow in gallons per minute instead of gallons per hour, we must convert the rate of flow to gallons per minute. A flow of 360 gallons per hour is 6 gallons per minute ($360 \div 60 = 6$).

(b) We must convert 30 pounds pressure to feet of head ($30 \times 2.31 = 69.3$).

(c) We have 69.3 feet of head to overcome friction, but Table II gives the friction for 100 feet of pipe and in this problem we have 250 feet. By dividing 69.3 by 250 and multiplying the quotient by 100, we find that 69.3 feet of head for 250 feet is the same as 27.7 feet of head for 100 feet.

(d) We then find the figure "6" in the column of Table II headed "Gallons Per Minute", and follow across the table from "6" until we come to the first figure that is equal to or below 27.7. We find this figure to be "18" in the column headed "3/4 inch Pipe".
(e) The correct pipe size would be 3/4 inch.
(f) You will notice that a flow of 6 gallons per minute through 100 feet of 3/4 inch steel pipe will produce only 18 feet of friction head while we have 27.7 feet of head to be overcome by friction. This means that the actual flow will be somewhat faster than 6 gallons per minute. However, we cannot use 1/2 inch pipe because a flow of 6 gallons per minute through it would require 130 feet of head per 100 feet of pipe.

Problem No. 3 - If, in Figure I, there are 75 feet of 1/2 inch copper tubing from which we want the water to flow at a rate of 600 gallons per hour, what must the pressure be in the tank?

Solution to Problem No. 3-
(a) Six hundred gallons per hour is 10 gallons per minute.
(b) By referring to Table I, we find that 10 gallons per minute through 100 feet of 1/2 inch copper tubing produces 150 feet of friction head.
(c) Seventy-five feet is 3/4 of 100 feet, so 10 gallons per minute through 75 feet of 1/2 inch copper tubing would produce 3/4 of 150 feet of friction head or 112.5 feet of friction head.
(d) 112.5 feet of head is 48.8 pounds per square inch (112.5 x .434 = 48.8) which would be the required pressure.

Figure 2 is like Figure 1 except that in Figure 2 the pressure in the tank must lift the water in addition to overcoming pipe friction.

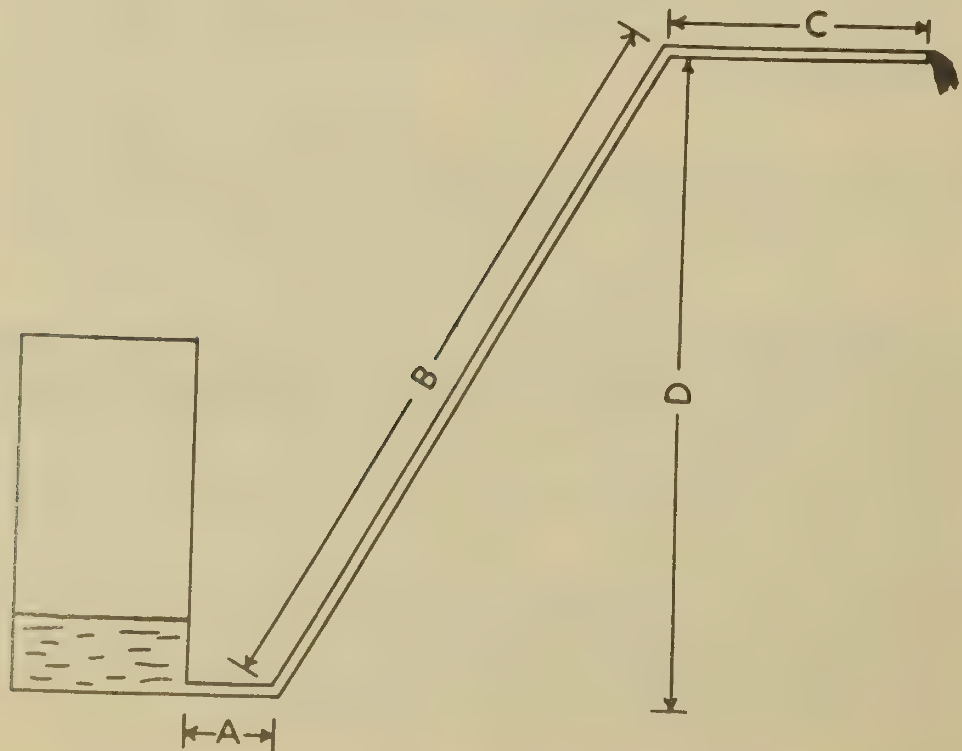

Figure 2

Let us work out a few problems from Figure 2.

Problem No. 4 - If the pressure in the tank (Figure 2) is 20 pounds, if 1 inch steel pipe is used having a total length (distances A + B + C) of 312 feet, if there are two 90° elbows in the pipe, and if the water is lifted 15 feet (distance D), how fast will water flow from the pipe?

Solution to Problem No. 4 -

(a) The 20 pounds pressure is 46.2 (20 x 2.31) feet of head.
(b) Lifting the water 15 feet will use up 15 of the 46.2 feet of head, leaving 31.2 feet of head to overcome friction.
(c) Table III gives the friction in a 1 inch 90° elbow as equal to that of 3 feet of straight pipe. The two elbows will add as much friction as 6 feet more of straight pipe.
(d) The total length of pipe is 312 feet, but the two elbows raise the amount of friction to the equivalent of that in 318 feet of pipe.
(e) Since we have 31.2 feet of head to overcome the friction in the equivalent of 318 feet of pipe, we have 9.8 feet of head per 100 feet of pipe.
(f) By following down the column headed "1 Inch Pipe" in Table II we find that a flow of 9 gallons per minute would require 9.3 feet of head and a flow of 10 gallons per minute would require 11 feet of head. Since our figure of 9.8 is between 9.3 and 11, the flow would be between 9 gallons per minute and 10 gallons per minute.

Problem No. 5 - (Refer to Figure 2). We are using copper tubing, there are two 90° elbows in the tubing, the tubing is 560 feet long (distance A + B + C), we want water to flow at a rate of 10 gallons per minute, the water is lifted 25 feet (distance D), and we have 25 pounds pressure in the tank, what size tubing do we need?

Solution to Problem No. 5 -

(a) 25 pounds of pressure is 57.8 feet of head (25 x 2.31 = 57.8).
(b) 25 feet of head will be used in lifting the water, leaving 32.8 feet of head to overcome friction.
(c) Assume that the friction in each elbow is equal to that in 10 feet of tubing. The two elbows will add as much friction as 20 more feet of pipe.
(d) Since the tubing is 560 feet long, the friction in the tubing and elbows will equal that in 580 feet of tubing.
(e) 32.8 feet of head to overcome friction in 580 feet of tubing is the same as 5.7 feet of head to overcome friction in 100 feet.
(f) By referring to Table I we see that a flow of 10 gallons per minute will require 1-¼ inch tubing. (This flow through 1 inch tubing would require 7.3 feet of head per 100 feet.)

For our next problems let us take situations that might occur when farmers water their gardens, and determine the correct sizes of pipes. In actual practice, we seldom have the water flowing in open discharge from the ends of our pipes and we often have devices on the ends, such as sprinklers, which require certain amounts of pressure for satisfactory operation. Usually there will be a garden hose to consider. Table IV gives the pressure loss due to friction in garden hose. Since garden hose is commonly sold in 25 foot and 50 foot lengths, Table IV gives the friction loss in those lengths of hose. The loss in other lengths would be directly proportional to the lengths.

TABLE IV

FRICTION OF WATER IN USUAL GARDEN HOSE

Loss of Head in Feet Due to Friction in Usual Garden Hose

Rate of Flow GPH	Size of Hose 5/8 Inch		3/4 Inch	
	Per 25 ft.	Per 50 ft.	Per 25 ft.	Per 50 ft.
200	1.10	2.20	.577	1.15
225	1.36	2.72	.722	1.44
250	1.63	3.26	.867	1.73
275	1.94	3.88	1.04	2.08
300	2.27	4.54	1.21	2.42
325	2.63	5.26	1.42	2.83
350	3.00	6.00	1.62	3.24
375	3.40	6.80	1.83	3.65
400	3.81	7.62	2.08	4.16
425	4.22	8.44	2.32	4.64
450	4.68	9.36	2.60	5.20
475	5.08	10.16	2.86	5.71
500	5.66	11.32	3.15	6.29
525	6.18	12.36	3.44	6.88
550	6.70	13.50	3.73	7.45
575	7.22	14.44	4.04	8.09
600	7.80	15.60	4.39	8.78

Problem No. 6 - In watering his garden, a farmer will use his farmstead pump and will need the following:

(a) 220 feet of underground pipe with 1 gate valve, 1 tee, 5 - 90° elbows.
(b) One frost-proof hydrant in the center of his garden.
(c) A 50 foot length of 3/4 inch garden hose to reach from the hydrant to the various locations of his portable sprinkler.
(d) One portable sprinkler.

What size pipe should he use if the garden and the pump are at approximately the same elevation?

Solution to Problem No. 6 -

(a) We investigate the farmer's pump and find that the automatic switch stops it when the pressure reaches 40 pounds. In order

that it shall run continuously while the garden is being watered, its full capacity must be delivered to the garden when the pressure at the pump is below 40 pounds. We arbitrarily select 30 pounds as the pressure at which we are going to have the pump operate. This is enough below 40 pounds so that unforseen variations from our estimates will not cause the actual pressure to be as high as 40 pounds. We find that at 30 pounds pressure the pump will deliver 325 gallons per hour.

(b) We select a portable sprinkler which will deliver 325 gallons per hour at 20 pounds pressure. This will leave 10 pounds pressure to be used up in overcoming friction in the pipe and garden hose.

(c) 10 pounds is 23.1 feet of head (10 x 2.31 = 23.1).

(d) By referring to Table IV we find that a flow of 325 gallons per hour through 50 feet of 3/4 inch garden hose will use 2.83 feet of head. This leaves 20.27 feet of head to overcome the friction in the pipe and hydrant.

(e) Since the frost-proof hydrant is essentially a very short piece of pipe with an elbow on each end, we can consider it as being equal to two elbows when we figure the amount of friction.

(f) If we assume that the friction in each elbow and tee is equal to that in 10 feet of pipe, the 1 tee, 5 elbows, and 1 hydrant will have friction equal to 80 feet of pipe.

(g) Since the actual length of pipe is 220 feet, the friction in the pipe and its fittings will be equivalent to that in 300 feet of straight pipe.

(h) We have 20.27 feet of head to overcome friction in 300 feet of pipe. This is 6.76 feet of head per 100 feet.

(i) 325 gallons per hour is approximately 5.4 gallons per minute.

(j) By referring to Table II we find that 1 inch pipe would be needed.

<u>Problem No. 7</u> - A farmer has a pump at his house that delivers 500 gallons per hour against 30 pounds pressure. He has 1-½ inch service pipe from his pump at the house to his barn. Fifty-five feet from the house he is going to put a tee in this service pipe and take off an underground pipe 187 feet long to his garden. A frost-proof hydrant will be placed in the middle of his garden and two sprinklers, fed by two 50 foot lengths of 3/4 inch garden hose, will be used simultaneously. The land slopes so that the sprinklers will be about 20 feet lower than the storage tank at the pump. What size pipe should he use to the garden?

<u>Solution to Problem No. 7</u> -

(a) The total pressure available is the 30 pounds per square inch in the tank, plus the 20 foot difference in elevation between the tank and the sprinklers. Since 20 feet of head is 8.7 pounds per square inch, the total pressure available when the pump is operating against 30 pounds pressure is 38.7 pounds.

(b) We select two portable sprinklers, each of which will deliver 250 gallons per hour at 30 pounds pressure. This will leave us 8.7 pounds of pressure to overcome friction in the pipe and garden hose
(c) 8.7 pounds is 20 feet of head.
(d) Each of the 50 foot sections of garden hose will be carrying water at a rate of 250 gallons per hour. Table IV shows us that 1.73 feet of head will be needed to overcome the friction in these hoses. This leaves us 18.3 feet of head to overcome the friction in the pipes and hydrant.
(e) The first 55 feet of pipe from the pump is 1-¼ inch. Table II shows that 500 gallons per hour (approximately 8.3 gallons per minute) through 100 feet of 1-¼ inch pipe requires between 2.4 and 3.1 feet of head to overcome friction. The actual amount would be about one-third of the way between these two figures or about 2.6 feet of head. 2.6 feet of head per 100 feet of pipe is 1.4 feet per 55 feet of pipe.
(f) Subtracting 1.4 from 18.3 leaves 16.9 feet of head to overcome the friction in the 187 feet of new pipe and the hydrant.
(g) If we assume that the friction in the hydrant and the tee are equal to that in 30 feet of pipe, the friction in these fittings and the pipe will equal that in 217 feet of pipe.
(h) 16.9 feet of head in 217 feet of pipe is the same as 7.8 feet of head per 100 feet.
(i) By referring to Table II, we see that in a 1 inch pipe a flow of 8 gallons per minute would require 7.4 feet of head and a flow of 9 gallons per minute would require 9.3 feet of head. The 7.8 feet of head that we have would give us our required flow of 8.3 gallons per minute and 1 inch pipe would be the correct size.

HOW SHOULD WATER BE DISTRIBUTED OVER THE GARDEN?

There is a wide variety of ways of distributing the water over the garden. Probably the most common and the most universally applicable method is to use portable sprinklers supplied by garden hoses. This method does not require a large investment in equipment, it requires comparatively little work, it is simple to use, and it is satisfactory on practically all plants, on practically all soils, and under most topographic conditions.

Perforated pipe sprinklers are widely used by operators of commercial truck patches and market gardens. They consist of one or more pipes extending across the garden with a series of small holes or nozzles which spray the water over an area of 20 to 50 feet on either side. They receive water from a pipe or hose extending along the side of the garden. Some of them are portable, being made of light-weight pipe which lies on the ground. Others are stationary and are mounted on specially placed poles. Systems using perforated pipe are relatively expensive and usually require a faster flow of water than can

be obtained from the regular farmstead pump. For these reasons, they are not well suited to most home garden watering, but they can be used on practically all plants, on practically all soils, and under most topographic conditions.

Porous hoses are often used. These are hoses of canvas duck closed at one end and equipped with couplings for connection to garden hoses at the other end. Water oozes from the porous hose throughout the entire length. Because of the frequency with which they must be moved they are usually satisfactory only in very small gardens. They must be laid practically on the contour. Water is supplied to them by ordinary garden hoses.

Gardens are sometimes watered by the furrow method. The water is allowed to flow through furrows between the rows. While this method requires very little special equipment, it does require more work than any other method, and can be used only on certain soils and with rather smooth topography.

Occasionally, underground tile lines are used for garden watering. In some soils this method is quite satisfactory. It requires a large amount of water and shallow, close-spaced tile lines laid exactly level. Water is fed to the lines through a header at the end or side of the garden. Sometimes the same tile lines are used for both watering and drainage. This method is little used because of the work and cost of making the original tile installation.

HOW DO WE CHOOSE THE RIGHT SPRINKLER?

The variety in sprinklers is so great that it is impractical to attempt to discuss all variations that may be found. Also, some types, such as perforated pipe, use water faster than it can be supplied by the more common farmstead water pumps. This discussion will be limited to some of the more common types that are suitable to use in garden watering.

Sprinkler type watering can be used on level, sloping, or uneven gardens, and on any type of soil. It is easier to regulate the evenness of the distribution of the water with sprinklers than with furrow or porous hose watering.

No sprinkler will give a perfectly uniform distribution of water over the sprinkled area, although some of them do much better in this respect than others. Those that are built for irrigation purposes are usually much better than the cheaper lawn type. It is necessary to overlap the sprinkled areas considerably - usually about 50 percent - to assure that the entire garden is adequately watered. Wind affects the distribution of water from a sprinkler considerably.

Portable sprinklers can be divided into those with stationary sprinkling heads and those with rotating or oscillating sprinkling heads.

Stationary Sprinkler Heads

Sprinklers with stationary heads are usually cheap devices. They are designed for watering lawns and cover only very small areas at each setting. Because of the limited areas covered by these devices at each setting, they are suitable only for small gardens. On many farm gardens, the number of different settings necessary to cover the whole area would be such a nuisance that this type of sprinkler would not be satisfactory. Often, they distribute water as fast as sprinklers covering much larger areas. To avoid excessive run-off it is sometimes necessary to move them before the ground has become adequately soaked. Most of these sprinklers throw a circular or fan-shaped spray, although a few of them throw a cone-shaped spray straight upward. Some people prefer the fan-shaped spray since this wets the ground in only one direction from the sprinkler and the sprinkler can be approached and moved while it is operating without getting wet or getting the shoes muddy.

Oscillating Sprinkler Heads

Oscillating sprinkler heads usually throw a fan-shaped spray, but the mechanism is made so that the spray is thrown first to one side and then to the other. They are not as common as either the stationary heads or the rotary heads. Most of them are lawn-type sprinklers. They may apply water more rapidly than is desirable in the garden. The area that they cover is greater than that of most stationary heads but is not nearly as large as that covered by some of the rotary heads. They are better built devices, and more expensive, than most of the stationary heads. This better construction results in more uniformity of performance between two apparently identical sprinklers than is true of cheaper ones.

Rotating Sprinkler Heads

The most common, by far, of the sprinklers used for garden watering use rotating heads. In general, these are to be most highly recommended.

We can divide sprinklers with rotating heads into two groups, (1) those that are built for lawn watering and (2) those that are built for irrigation. This is not a fixed classification and there are some sprinklers that would be difficult to classify into one or the other group, but, as a usual thing, the lawn-type sprinklers are relatively cheap devices while the irrigation-type are better built, are more uniform, and give a more even distribution of water. Many of the cheaper lawn-type sprinklers will place water unevenly and as fast over an area 30 feet in diameter as a better irrigation-type will place fairly evenly over an area 80 feet in diameter. Some of the better irrigation-types will water an area that is approximately square. Some of them can be adjusted so that they cover only part of a circle rather than the complete circle.

There is a wide variety of types of nozzles in use on the lawn-type sprinklers so that exceptions can be found to almost anything that is said about them. Most of the irrigation-types have plain nozzles that are rather accurately made to standard sizes. The rate at which water will pass through these plain nozzles depends on the size of the opening and the pressure in the sprinkler. Table V shows the rate at which different size nozzles can be expected to deliver water.

TABLE V
RATE OF WATER FLOW THROUGH FOUR SIZES OF SPRINKLER NOZZLES

Pounds Pressure	G.P.H. Through 1/8" Nozzle	G.P.H. Through 5/32" Nozzle	G.P.H. Through 3/16" Nozzle	G.P.H. Through 7/32" Nozzle
20	118	182	260	350
25	131	206	292	390
30	146	227	323	430
35	160	246	350	470
40	172	264	376	500

Note: G.P.H. means gallons per hour

The area covered by a rotating sprinkler head at one setting depends on the size of the nozzle, the pressure in the sprinkler, the angle (from the horizontal) at which the water is discharged into the air, and the speed of rotation of the head. A rapidly rotating head will cover a much smaller area than will a slowly rotating one. The height of the nozzle above the ground also has some effect on the area covered.

Perhaps the significance of having a sprinkler that covers a large area at each setting can best be shown by drawings.

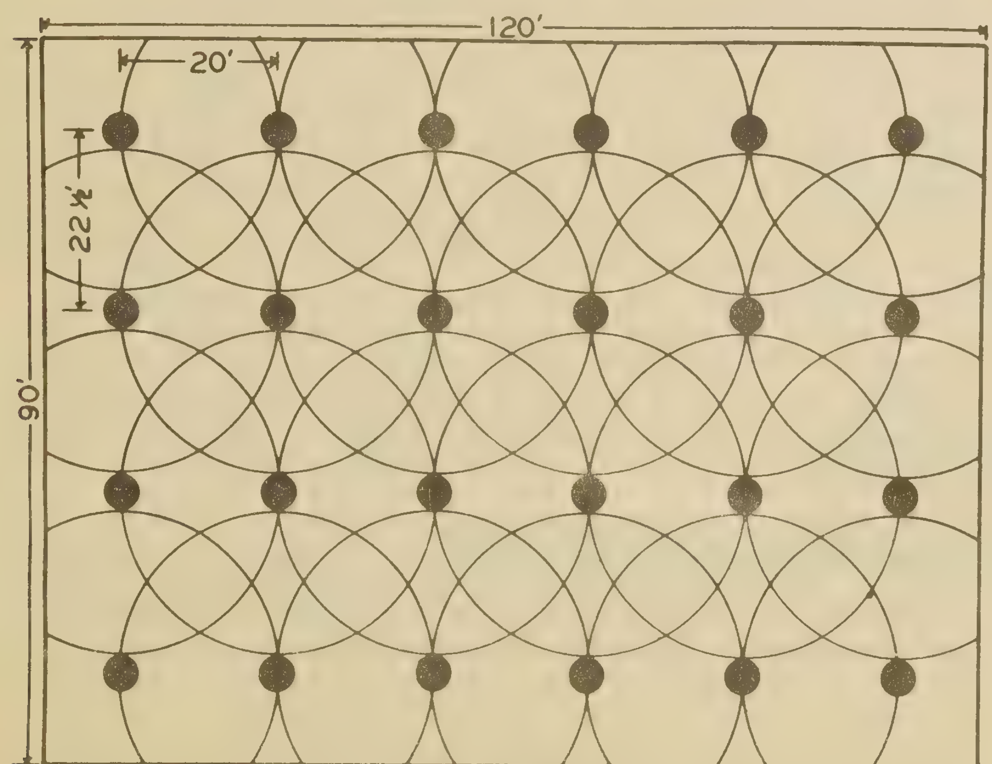

Figure 3

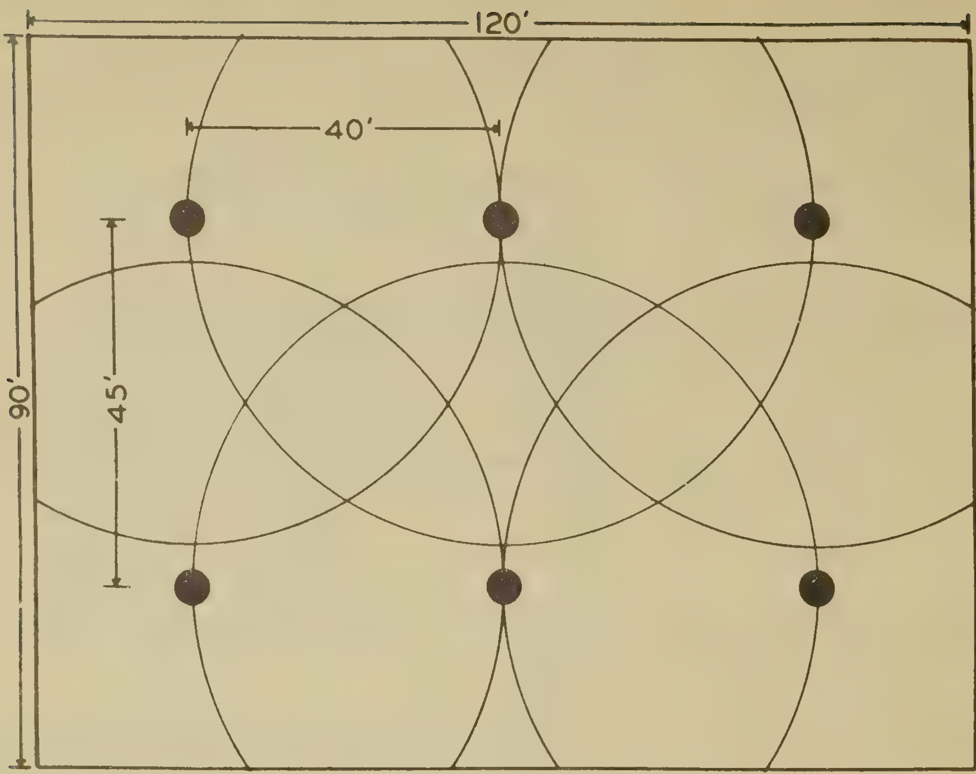

Figure 4

Both Figures 3 and 4 show gardens 120 feet long by 90 feet wide. The one in Figure 3 is being watered by a sprinkler that covers a circular area 40 feet in diameter while the one in Figure 4 is being watered by a sprinkler that covers an 80 foot diameter. The black dots represent the various sprinkler settings and each circle represents the area watered when the sprinkler is at its center. Notice that the two sketches have been drawn to show the same pattern of water distribution over the garden. In both cases, practically every spot is watered from at least two different sprinkler settings except for a small area in each corner and a few little areas along each side. However, the most significant thing to notice is that 24 settings of the 40 foot sprinkler are needed to do the job that 6 settings of the 80 foot sprinkler would do. Cutting the diameter of the sprinkled area in half will always make necessary 4 times as many settings of the sprinkler to get the same pattern of coverage. Using a sprinkler that covers a large circle has two definite advantages. It substantially reduces the work and bother involved in moving the sprinkler, and it spreads the water over a larger area at each setting so that at the same rate of flow there will be less run-off.

<u>How Fast Should A Sprinkler Deliver Water?</u>

If we are going to eliminate undue wear on the pumping machinery, water must be placed on the garden at the same rate that the pump pumps it. For example, if the pump delivers water at a rate of

360 gallons per hour, we must have one sprinkler that delivers 360 gallons per hour, or two sprinklers each of which delivers 180 gallons, or three sprinklers each of which delivers 120 gallons, and so on. The other important thing is that water must be placed on the soil slowly enough so that it soaks in instead of running off. The maximum rate at which it will not run off depends on the soil and the slope. If we have three sprinklers each of which delivers water at a rate of 360 gallons per hour but one covers a 20 foot circle, another a 40 foot circle, and the third an 80 foot circle, the one covering a 20 foot circle will place 10.3 gallons per hour on each square yard of soil, the one covering 40 feet will place 2.6 gallons on each square yard, and the 80 foot one, 0.65 gallons.

HOW IS POROUS HOSE USED?

Porous hose is made of canvas duck usually of 8, 10, 12, or 14 ounce weight. It may be 2 to 3 inches in diameter and commonly comes in either 25 foot or 50 foot lengths. The rate at which water is applied depends on the weight and weave of the canvas, the water pressure at the hose, and the length of the hose. The variations in different porous hoses that are available are so great that no fixed statements can be made about the rate that they will deliver water, but for preliminary estimates it may be assumed that 50 feet of 8-ounce hose will require about 300 gallons per hour, although this will vary widely. At any specified pressure, the same length of heavier hose of the same diameter will deliver less water.

Under some conditions porous hose can be used satisfactorily but it usually requires frequent attendance. It is laid between two rows and within a short time will have delivered enough water to that space. It must then be moved to the next row space. Due to the rate at which water is applied to a relatively small area, on many soils it will run off before the soil is adequately soaked. If a small size, heavy duck hose is used so that the water is applied more slowly, several hoses in use simultaneously may be needed to keep the pump running. It is also necessary that each section of hose be laid practically level throughout its entire length. If one place on a section is somewhat downgrade from another place, the lower place will deliver more of the water.

On small, level gardens, particularly with the more porous soils, porous hose watering is often quite satisfactory.

Since porous hose is made of canvas, it will mold and rot quickly if it is left damp. Some of it is specially treated to prevent mildew. Such treatment may reduce the damage, but the hose should never be left lying on the damp ground after watering is completed, and it should be hung up to dry as soon as it is removed from the garden.

A comparison of the amount of work involved in moving porous hose and in moving a sprinkler can be obtained by comparing the area that each covers at one setting. If we assume that the garden rows are 2 feet apart, a 50 foot length of porous hose will water 100 square feet at each setting. A sprinkler covering an area 40 feet in diameter will water 1,257 square feet at each setting. Since sprinkled areas must be overlapped, we can assume that each setting of the sprinkler will cover 600 square feet of new area. Evidently six 50 foot lengths of porous hose would be needed to do the work of one 40 foot sprinkler. Of course, if the rows were 3 feet apart, four 50 foot lengths of porous hose would do the same work.

HOW IS THE FURROW METHOD USED?

Watering by the furrow method requires the least equipment of any method but it also requires the most labor. The rows must be level or with a slight slope toward the far end, and the soil must be tight enough so that water will flow to the far end of the furrow before it all soaks in. A furrow must be dug or plowed between the rows. When water is allowed to run into one end of this furrow it will flow to the other end, watering the full length.

Often, it is desirable to water several rows at once. The most convenient way of doing this is to use a V-shaped trough. This trough is built long enough to extend across several rows at one time and holes one-half inch or larger are bored in one side, spaced the width of the rows. These holes must be in a straight line parallel to the length of the trough. The trough is set level and crosswise to the rows being watered. The hose is placed in the trough and the water turned on. As the water rises in the trough, it runs from each of the holes and down the furrows between the rows. A little experimenting will be necessary to get a trough of the right length and holes of the right size so that the pump will run continuously without overflowing the trough. Since the use of a trough waters several rows at once, it applies water slower to each row and makes less frequent moving of the garden hose necessary. The trough should be moved to a new location when the soil has been well soaked at one location.

It may be desirable to connect furrows between rows at the far end. This will allow water which reaches the far end to return between the next rows. If the rows are quite short, the furrows can sometimes be connected at their ends so that the water flows across the garden between two rows and back between the next two. This may make it possible to water several rows without moving the hose.

WHAT DOES GARDEN WATERING COST?

It is impossible to tell here what the equipment to water any particular garden will cost, but often the benefits from one season's use will pay for it.

Unless the garden is within a few feet of a building with a sill cock or wall hydrant on the outside of it, a pipe to the garden with a frost-proof hydrant in the garden will be needed. A garden hose will be needed to reach from the hydrant to the place where the water is distributed. Usually, one or more sprinklers or one or more sections of porous hose will be needed.

To illustrate the possible cost of equipment, let us assume that we are going to water a 90 ft. by 120 ft. garden. Suppose we are going to use a sprinkler covering an 80 foot circle, that 200 feet of pipe will be needed from the pump to the hydrant, and that the pump delivers 325 gallons per hour. The following materials might be needed and the costs given might apply.

220	feet of	1-inch galvanized pipe @ \$0.20 per foot	\$44.00
1		1-inch galvanized tee	.39
5		1-inch 90° elbows @ \$0.26 each	1.30
1		frost-proof hydrant	10.95
50	feet of	3/4-inch garden hose	8.25
1		rotary sprinkler	9.00
1		sprinkler stand	1.50
			\$75.39

If the well is not over 100 feet deep, it is likely that between 4 and 10 kilowatt hours of electricity will be used each time one inch of water is put on one-fourth acre.